Faculty of Manufacturing Engineering

DEVELOPMENT OF COMPUTER ERGONOMICS RISK ASSESSMENT (COM-ERA) TOOL FOR ASSESSING WORK-RELATED MUSCULOSKELETAL DISORDERS (WMSDS) ASSOCIATED WITH COMPUTING TASKS

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DEVELOPMENT OF COMPUTER ERGONOMICS RISK ASSESSMENT (COM-ERA) TOOL FOR ASSESSING WORK-RELATED MUSCULOSKELETAL DISORDERS (WMSDS) ASSOCIATED WITH COMPUTING TASKS

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DECLARATION

I declared that this report entitled "Development of Computer Ergonomics Risk Assessment (COM-ERA) Tool For Assessing Work-Related Musculoskeletal Disorders (WMSDS) Associated with Computing Tasks" is the result of my own research except as cited reference. The thesis has not been accepted for any degree and is not currently submitted in candidature of any other degree.

Signature :
Name : TOO YI WEI
Date :

APPROVAL

I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of Master of Manufacturing Engineering (Industrial Engineering).

Signature :
Supervisor Name : DR. ISA BIN HALIM
Date :

DEDICATION

To my parents,

Too Beng Hooi

Yeap Aye Ngoh

My beloved siblings and friends,

Without whom none of my success would be possible

ABSTRACT

The cases of work-related musculoskeletal disorders (WMSDs) among office workers who performing computing task are increasing recently. However, the ergonomics assessment tools developed have limitations in assessing risk factors and associated factors for WMSDs due to computing task workstation. The primary objective of this study was to develop a new ergonomics assessment tool, called as Computer Ergonomics Risk Assessment (COM-ERA) for assessing risk factors associated with WMSDs among computer users. An extensive literature review was performed to identify the risk factors and associated factors for WMSDs in computing task. A focus group discussion among ergonomics experts was conducted to finalize the COM-ERA framework and its scoring system. A case study was carried out to determine the validity of the COM-ERA tool using Nordic Musculoskeletal Questionnaire and quantitative physical tests (biofeedback and hand grip strength). All data were analyzed using Statistical Package for Social Science (SPSS version 13). Statistical analysis associated with Chi-square test shows that there was a good agreement between the COM-ERA tool results with the physical test in the neck (X^2 (1, N=10) = 0.023, p = 0.88), shoulder and arm (X^2 (1, N=10) = 0.47, p = 0.49), wrist (X^2 (1, N=10) = 0.74, p = 0.38), back (X^2 (1, N=10) = 1.2, p = 0.26), and leg regions (X^2 (1, N=10) = 0.47, p = 0.49). Additionally, a reliability test was conducted by comparing the COM-ERA scores of 20 observers using intra-class correlation (ICC) analysis. The COM-ERA scores exhibited high Intra-observer reliability (ICC = 0.89). This study concluded that the COM-ERA was proven to be a valid and reliable tool for assessing risk factors associated with WMSDs among computer users.

ABSTRAK

Lewat kebelakangan ini, kes gangguan otot berangka disebabkan kerja *(WMSDs)* dalam golongan pekerja pejabat semakin meningkat. Namun begitu, alat penilaian yang telah dibangunkan masih mempunyai kekurangan dalam menilai faktor-faktor risiko *WMSDs* dalam stesen kerja pengkomputeran. Tujuan utama penyelidikan ini adalah untuk membangunkan sebuah alat penilaian yang baru iaitu *Computer Ergonomics Risk Assessment (COM-ERA)* untuk menaksir faktor-faktor risiko *WMSDs* dalam kalangan pengguna komputer. Kajian ilmiah telah dibuat untuk mengenalpastikan faktor–faktor risiko *WMSDs* dalam tugasan pengkomputeran. Satu kumpulan fokus kajian antara pakar-pakar ergonomik telah diadakan untuk memuktamadkan kerangka kajian dan sistem pemarkahan *COM-ERA*. Kajian kes telah dilakukan untuk memastikan kesahan dengan menggunakan *Nordic Musculoskeletal Questionnaire* dan ujian fizikal kuantitatif (*biofeedback* dan ujian kekuatan genggaman tangan). Semua data telah dianalisa dengan *Statistical Package for Social Science* (*SPSS version 13*). Dapatan analisis statistik *Chi-square* menunjukkan bahawa persetujuan antara dapatan *COM-ERA* dan ujian fizikal telah dicapai pada bahagian leher (X^2 (1, N=10) = 0.023, p = 0.88), bahu dan tangan (X^2 (1, N=10) = 0.47, p = 0.49), pergelangan tangan (X^2 (1, N=10) = 0.74, p = 0.38), belakang (X^2 (1, N=10) = 1.2, p = 0.26), dan kaki (X^2 (1, N=10) = 0.47, p = 0.49). Selain itu, ujian kebolehpercayaan telah dijalankan dengan membandingkan skor COM-ERA antara 20 pemerhati dengan menggunakan analisis *intra-class correlation (ICC)*. Markah COM-ERA telah menunjukkan kebolehpercayaan *Intra-observer* yang tinggi (ICC = 0.89). Kesimpulannya, kajian ini telah membuktikan kesahan dan kebolehpercayaan *COM-ERA* untuk menaksir faktor-faktor risiko *WMSDs* di kalangan pengguna komputer.

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ART	-	Assessment of Repetition Tasks
BPI	-	Brief Pain Inventory
CANS	-	Complaints of the Arm, Neck or Shoulder
COM-ERA	-	Computer Ergonomics Risk Assessment
DOSH	-	Department of Occupational Safety and Health
EWA	-	Ergonomic Assessment Analysis
LERA	-	Lower Extremity Risk Assessment
LUBA	-	Loading on the Upper Body Assessment
MSD	-	Musculoskeletal Disorder
MUEQ	-	Maastricht Upper Extremity Questionnaire
NIOSH	-	National Institute of Occupational Safety and Health
OEA	-	Office Environment Assessment
OWAS	-	Ovako Working Posture Analysis System
PATH	-	Postures, Activities, Tools, and Handling
QEC	-	Quick Exposure Checklist
REBA	-	Rapid Entire Body Assessment
ROSA	-	Rapid Office Strain Assessment
RULA	-	Rapid Upper Limb Assessment
SOCSO	-	Social Security Organization
SPSS	-	Statistical Package for Social Science
UTeM	-	Universiti Teknikal Malaysia Melaka
VDT	-	Visual Display Terminal
WMSDs	-	Work-Related Musculoskeletal Disorder
PBU	-	Stabilizer Pressure Biofeedback Unit
ICC	-	Intra-class Correlation

CHAPTER 1

INTRODUCTION

This chapter introduces the background information of this study. The information in this thesis is organized to disclose the originality of this study. It renders both aspects of Work-Related Musculoskeletal Disorders associated with computing tasks in office workstations and statements justifying the rationale of this study. Descriptive information is also given on: background of study, problem statement, study objectives, scope of study and significance of study.

1.1 Background of Study

An office is a workplace where tasks such as professional duties and administrative works were performed by an organization staff. The work space provided in the office were used for conventional office work which included computer usage, reading, writing, records keeping and others, either in hard and soft format (Vimalanathan and Babu, 2014). Meanwhile, office workers are those who perform these tasks on daily basis. Their working environment were mainly in sitting position and equipped with chair, desk, computer, telephone and other equipment to perform their tasks (United States Department of Labour, 2012). The long hours spent working on the office task had made them to become vulnerable to Work-Related Musculoskeletal Disorders (WMSDs) (Dembe, 1998).

Generally, WMSDs included injuries related to muscle, ligament, nerves, tendons, joint and blood vessel (Santos et al., 2015). This occupational injury becomes a health challenge in general population (Lop et al, 2017). As the job demand in computing task required sitting for long hours, it can lead to lack of physical exercise (Shariat et al., 2016).

This work practice was potentially contributing to WMSDs which can caused pain and discomfort (Soe et al., 2015). According to Soe et al., (2015), around 70 % - 80 % of adults in industrialized countries will experience certain level of discomforts related to WMSDs when they have aged. Although office tasks might seem to be more comfortable compared to other jobs task such as manufacturing processes or construction works, however, this occupation was also exposed to WMSDs risks.

Recently the number of WMSDs in Malaysia has raised steadily. The National Institute of Occupational Safety and Health (NIOSH) of Malaysia showed that 61% of the Malaysian population used computer as their daily job equipment (Hassim, 2010). Since the computer become so important in the office, ergonomic risk factors related to computing task become the main hazard in causing WMSDs (OSHA, 2015). According to Tan Sri Lee Lam Thye, chairman of NIOSH Malaysia, there were 2630 occupational injuries reported in 2013. From these reported diseases, 694 of them were musculoskeletal disorder cases. In other word, this means that out of every four cases reported to Social Security Organization (SOCSO), there will be one related to the musculoskeletal disorder. Due to this, the compensation of the musculoskeletal disorder cases was found to be higher than other occupation injuries (Borneo Post, 2016).

Several studies have proven that computer task has caused WMSDs among workers. A study conducted by Poochadaa and Chaiklieng (2015) showed that most of the call center workers who experienced prolonged computer work were exposed to high risk of WMSDs. Oha et al. (2014) have showed that 77% of Estonia office workers using computers have reported musculoskeletal pain. The workers who suffered from neck pain, wrist pain, low back pain and shoulder pain have prevalence rate of 51%, 35%, 42% and 30% respectively (Oha et al., 2014). On the other hand, Shabbir et al. (2016) have also conducted a study among bankers who use computer workstation in their daily task. In their finding, they found

that 71.67% of the workers experienced neck pain while 48.33% of them experienced shoulder pain. Daneshmandi et al. (2017) also obtained similar findings when they found that office workers of Iranian suffered from neck, lower back pain and shoulder pain.

Many assessment tools have been developed in the past decades to assess the risk factors in workplace. However, not all of the assessment tools were suitable to be use to assess the risk factors in computer workstation due to their limitations (Rahman & Mohamad, 2016). For example, there are no existing tools that have covered all risk factors of the computer workstation (Rahman & Mohamad, 2016). Thus, the aim of this study was to develop a new ergonomic assessment tool called as Computer Ergonomics Risk Assessment (COM-ERA) which specifically used for assessing the risk of WMSDs among office computer users.

1.2 Problem Statement

The physical health of office workers were easily affected by their work nature. As office workers spent long hours doing computing task, they were vulnerable to the WMSDs (Dembe, 1998). WMSDs among office workers has led to sickness and absenteeism (Burdorf et al., 1998; Luime, 2005). To overcome this problem, assessment tools have been made to assist in identifying the risk factors or the appropriateness of the workstation design. However, there were limitations among the existing assessment tools.

Firstly, not all risk factors and associated factors that caused WMSDs in computer work were included in the assessment tools. One of the examples was the Rapid Entire Body Assessment (REBA) developed by Hignett and McAtamney (2000). REBA was specialized for postural analysis and it does not included the equipment used in the office environment for computer task. The Rapid Office Strain Assessment (ROSA) tool developed by Sonne et al., (2010) for computer work does not include all physical factors. For example, the ROSA

tool did not include the office environmental condition such as the temperature and lighting into the assessment tool (Sonne et al., 2010).

Secondly, most of the assessment tools developed were not specifically for computer users in office environment. Most of the study were for general ergonomic risks (Rahman & Mohamad, 2016). For example, the Rapid Upper Limb Assessment (RULA) tool was developed for general tasks that involve postural analysis (McAtamney & Corlett, 1993) while Quick Exposure Checklist (QEC) (David et al., 2008) was also used for assessing the exposure of upper body and limb for static and dynamic tasks (Rahman & Mohamad, 2016).

Furthermore, in the current existing assessment tools, some of them were not tested for the validity (Sukadarin et al., 2016; Rahman & Razak,2016). For example, in the study conducted by Rahman & Mohamad (2016), they have discovered that assessment tools such as the Assessment of Repetition Tasks (ART), Office Environment Assessment (OEA), and Computer Workstation e-Tool does not show any formal studies to test the validity. Since validation is an important part in developing assessment tool, it is necessary for the validity to be tested in the study.

Thus, this study was conducted to develop a new assessment tool, the Computer Ergonomics Risk Assessment (COM-ERA), which will overcome the problems mentioned earlier.

1.3 Objectives of Study

The objectives of this study are:

- To determine the risk factors and associated factors for WMSDs among office workers.
- To develop computer ergonomics risk assessment (COM-ERA) tool for assessing risk factors of WMSDs.
- To validate and test the reliability of COM-ERA tool.

1.4 Scope of Study

This study focused in developing and validating a new tool COM-ERA. The COM-ERA will focused on detailed physical factors, which consisted work related factors, office equipment or technology and the environment factors. The newly developed assessment tool was specifically for office computer users. This study also created a model which will quantify the physical risk variables into a set of equations that was able to approximate the total risk to different body regions of workers working in office computing task.

1.5 Significance of Study

This study has developed a new assessment tool (COM-ERA) which focused on computer task in the office working environment. This tool was able to fill the knowledge gap in understanding the risk factors that caused WMSDs in computing task in office environment. Besides that, the development of COM-ERA improved the quantitative assessment of risks that were related to WMSDs among workers working using computer. The tool developed will be able to assess the physical risk factors and associated factors that can affect the productivity of an organization.

CHAPTER 2

LITERATURE REVIEW

In the first chapter, the background of study related to the organization of the studies is discussed. This chapter will proceed with a fully referenced review from relevant literatures. The primary objectives of the review are to identify the following information: the fundamental of computing task; risk factor and associated factor in computer workstation causing WMSDs, and limitation of the current existing tools. At the end of the chapter, summary of the knowledge gap between the previous study and this study related to computing task are provided.

2.1 Risk Factor and Associated Factor for WMSDs in Computing Task

Today, at least 50% from the world's population are working using computer (Vimalanathan and Babu, 2014). Even in Malaysia, it has been stated that 61% of the people used computer in their workplace (Hassim, 2010). Computing task involved using a computer to carry out activities such as storing information, process the information, data or other task such as calculating or organizing words (Barata, 1999). Computing task can be seen in bank workers (Moom et al., 2015), Information Technology (IT) Services, web designers, teachers, video production workers and others related occupations. These people worked in office environment where they spent 80 - 90% of their working time in office indoor (Vimalanathan and Babu, 2014). Computer was also referred as Visual Display Units (VDU). Workforce using VDU used computer mouse as their input device and were maintained in seated position for a long time (Wahlström, J., 2005). Normally, the workers

have to sit for about 8 - 9 hours with limited physical exercise (Shariat et al., 2016). Therefore, it is important that the risk factors of the office environment can be access easily to provide a safe and healthy workplace for the computer users working in office environment.

2.1.1 Work Related Musculoskeletal Disorders (WMSDs)

Musculoskeletal Disorder (MSD) referred to a wide range of conditions that can affect any part of the musculoskeletal system. Musculoskeletal system referred to the nerve, muscle, bones, spinal discs and joints. MSD can also affect the supporting blood vessels and connective tissue such as ligaments, cartilages and tendons. Injuries such as sprains, strains, tears and any other acute or chronic soreness can happened within the musculoskeletal system and connective tissues (Shariat et al., 2016). The damages caused by MSD included pain, discomfort and loss of function the neck and back as well as extremities. Depending on the type of affliction, the injuries caused by MSD included tenosynovitis, carpal tunnel syndrome, tendonitis, bursitis, and others. These injuries were common among working people regardless any industries. (Simoneau et al., 1996). Musculoskeletal disorder was also the leading cause of work related disability among men and women aged from 16- 72 years old (Ministry of Health Malaysia, 2009). Work Related Musculoskeletal Disorder or known as WMSDs is the defined as musculoskeletal disorder caused or aggravated primarily the work performances and the immediate working environment (Pinder et al., 2007). Inyang et al. (2012) commented that WMSDs was developed over time and caused by either the work or the working environment. WMSDs can be found in many forms such as cumulative trauma disorder, repetitive strain injuries, carpal tunnel syndrome, overuse syndrome and repetition motion disorder (Inyang et al., 2015). According to Simoneau et al., (1996), even though it was unclear that how the onset mechanism are establish, it is still believed that

WMSDs was the injuries resulted from overuse and was beyond the body's recovery capacity.

WMSDs can be in many forms and each of them have different risk factors. The sources of WMSDs were generally from combinations of several factors. For example, a non-neutral posture while working can contributed significantly to create WMSDs even if there was low level of repetition. Conversely, if a person adopts a neutral work posture but there is high demand in the repetition task, it is still enough to cause WMSDs (Simomeau et al., 1996). Da Costa et al., (2010) explained that it is not an easy task to fulfill all criteria to identify a causal relationship between risk factor and WMSDs in a single paper. Therefore, studies related in integrating the factors to the different type of WMSDs has become significant so that the level of evidence of each relationship can be evaluated (Costa et al., 2010).

It is reported that many countries, no matter the developed or developing countries, have major concerns in WMSDs as it affected the public's health. Besides that, WMSDs affected the peoples' life quality and was also economically burden. This was because treatment for WMSDs involved cost, lost wages and productivity (Reddy & Yasobant, 2015). For example, in the period of 2009 until 2014, from the data provided by Social Security Organization of Malaysia (SOCSO) it indicated that there were 534 cases of injuries related to WMSDs and this have cost a total of RM 152,754 for the compensation cost (Rohani et al., 2016). WMSDs have not only increased the cost to society as there was the need for treatments, rehabilitations and also compensation costs (Podniece et al., 2008).

2.1.2 Risk Factors and Associated Factors of WMSDs

The physical risk factors were classified into three parts which included work related factors, environment factors, and equipment and technology. Work related factors and